

PATENT SPECIFICATION

(11)

1572 177

1572 177

- (21) Application No. 47030/76 (22) Filed 11 Nov. 1976 (19)
 (31) Convention Application No. 631 855 (32) Filed 14 Nov. 1975 in
 (33) United States of America (US)
 (44) Complete Specification published 23 July 1980
 (51) INT. CL.³ B32B 3/12 3/24
 (52) Index at acceptance

B5N 0312 0324
 E1B 1A2D 1C3B 1C3F 1C5A 1C5X 1C7 1F1A 1J6B

(72) Inventors CHARLES J. SAYLOR,
 RICHARD G. HAWORTH
 and LYLE F. YERGES



**(54) IMPROVEMENTS IN OR RELATING TO INTERIOR SPACE DIVIDING
 WALLS AND PANELS THEREFOR**

(71) We, HAWORTH MFG. INC., a corporation organized and existing under the laws of the State of Michigan, United States of America, of 545 East 32nd Street, Holland, Michigan 49423, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an interior space dividing wall formed of a plurality of panels and, in particular, to panels therefor.

Wall structures formed from a plurality of interconnected, prefabricated and portable panels are used extensively in commercial and industrial buildings for dividing interior regions into smaller work regions.

Such structures have proven particularly effective in providing greater privacy within the building, and at the same time improving the interior appearance. For this purpose, the panels are provided with many different exterior finishes, such as coloured plastics, carpets and fabrics. Some of these panels also tend to minimize noise, particularly when they are provided with soft exterior finishes, such as by being covered with carpeting or fabric. Many panels of this type are also provided with slotted rails extending vertically along the edges thereof, whereupon fixtures such as desks, shelves, filing cabinets and the like can be mounted on the panels. Due to the desire to mount these fixtures on the panels, the panels thus must be provided with substantial strength and, accordingly, are normally provided with a relatively strong and rigid core so as to provide the necessary strength.

While panels of the above type do tend to minimize noise, nevertheless any noise

absorption capability of the panel is normally provided solely by the outer coverings. Further, since these panels are normally of a height substantially less than the floor-to-ceiling height, this also permits the transmission of substantial noise over the panel which, when coupled with the inability of these panels to absorb a high percentage of sound at various frequencies, thus results in these panels being totally unacceptable for use in situations where a high noise reduction and absorption by the panel is necessary. Because of this inability to absorb a high percentage of the sound in the environment, these known panels have conventionally been referred to as non-acoustical-type panels.

In an attempt to provide a panel capable of absorbing a high percentage of directed sound at various frequencies, there are several so-called "acoustical-type" panels which are more effective in absorbing the environmental noises surrounding the panels. However, to achieve this noise absorption capability, these panels normally comprise a fiberglass core with fabric coverings thereover, the core being surrounded by a rectangular frame which constitutes the sole structure for providing the panel with structural strength. These panels, due to the lack of any structural strength. These panels, due to the lack of any structural strength in the core, do not possess the strength and rigidity necessary to permit fixtures such as shelves and the like to be hung thereon. Further, these known acoustical panels possess limited durability and are easily damaged due to the softness and lack of strength possessed by the core of the panel.

In recognition of the need for an acoustical panel, the American Society of Testing Materials (ASTM) has defined an industry

45

50

55

60

65

70

75

80

85

standard for testing the sound absorption quality of movable partitions, which standard is defined in ASTM regulation C423-66. This regulation requires that a panel or partition be tested at sound wave frequencies of 250, 500, 1000 and 2000 cycles per second. The panel is rated on a scale of from 0 to 100, and the greater the sound absorption capability of the panel, the higher the numerical rating. This numerical rating, which is normally referred to as the Noise Reduction Coefficient (NRC), is averaged over the four test frequencies set forth above. At the present time, some panels which are capable of having fixtures hung thereon normally have an NRC in the range of 30 to 45, whereas other known acoustical panels which utilize a core constructed totally of fiberglass are relatively weak and unstable, and often do not permit fixtures and the like to be hung thereon.

According to the present invention, there is provided an interior space dividing wall formed from a plurality of portable interior upright space divider panels which are horizontally connected together in series, at least some of said panels being of an acoustical construction for absorbing sound waves, each said acoustical panel having opposed faces and a sound absorbing structure defined between said panel faces and extending substantially coextensively over the area thereof, in which the sound absorbing structure includes first means for absorbing sound waves of a first frequency, said first means including a plurality of first Helmholtz resonators tuned for absorbing sound waves of said first frequency, each of said first resonators being defined by a first interior chamber which is substantially closed and communicates with the surrounding environment through first opening means which opens through one of the faces of the panel, and second means for absorbing sound waves of a second frequency which is substantially different from said first frequency, said second means including a plurality of second Helmholtz resonators each tuned for absorbing sound waves of said second frequency, each of said second resonators being defined by a second interior chamber which is substantially closed and communicates with the surrounding environment through second opening means which opens outwardly through one of the faces of the panel.

The present invention will now be described in more detail, solely by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a wall or partition system formed from two pre-fabricated movable panels which do not embody the present invention.

Figure 2 is an enlarged, fragmentary per-

spective view of the internal structure of one of the acoustical panels shown in Figure 1.

Figure 3 is an enlarged, fragmentary sectional view taken substantially along the line III—III in Figure 2.

Figure 4 is a fragmentary sectional view illustrating the core structure of the panel, same being viewed substantially along the line IV—IV in Figure 3.

Figure 5 is a view similar to Figure 4 but illustrating an embodiment of the present invention.

Figure 6 is a view similar to Figure 3 but illustrating an embodiment of the present invention, and

Figure 7 is a fragmentary sectional view of the core structure taken substantially along the line VII—VII in Figure 6.

Certain terminology will be used in the following description for convenience in reference only and will not be limiting. For example, the words "upwardly", "downwardly", "leftwardly" and "rightwardly" will refer to directions in the drawings to which reference is made. The words "inwardly" and "outwardly" will refer to directions towards and away from, respectively, the geometric center of the panel and designated parts thereof. Said terminology will include the words specifically mentioned, derivatives thereof and words of similar import.

A wall system can be formed from a plurality of walls embodying the present invention. A panel for a wall which embodies the invention in a preferred form comprises a movable, portable, prefabricated panel having the capability of absorbing substantial quantities of air-born sound waves of different frequencies. This panel is formed by a large sheetlike core positioned within and connected to a surrounding rectangular frame. The frame, in the illustrated embodiment, is formed by elongated channel-shaped rails which have their adjacent ends fixedly connected together. The core structure includes a pair of substantially parallel honeycomb layers which are disposed directly adjacent one another and are bonded together. The cells of the honeycomb layers are isolated from one another by an intermediate sheet layer. A pair of thin structural skins, such as sheet metal skins, overlie the outer faces of the honeycomb layers and are each bonded to both the adjacent honeycomb layer and the surrounding frame. The skins each have a plurality of small openings formed therethrough so that substantially each opening communicates with a single cell in the underlying honeycomb layer. This opening and its relationship to the associated cell results in the formation of a Helmholtz resonator for absorbing sound waves of a

desired frequency. The skins are each covered by a layer of sound absorbing fibrous material, such as a layer of fiberglass. When fiberglass is utilized for this outer layer, then the fiberglass layer in turn is covered by a thin layer of decorative fabric. The numerous Helmholtz resonators as formed on each side of the panel permit the panel to absorb substantial quantities of sound waves having different frequencies to thereby provide the panel with a relatively high noise reduction coefficient.

In a preferred embodiment of the present invention, the honeycomb core structure includes several different cell sizes. For example, each of the honeycomb layers disposed adjacent opposite sides of the panel can have at least two different sizes of cells. As a further alternative, the honeycomb layer on one side of the panel can have cells of a first size, whereas the honeycomb layer on the other side of the panel can have cells of a second size which is substantially larger than the first size. By providing two or more sizes of cells, the capability of the panel for absorbing sound waves of different frequencies is substantially increased.

Figure 1 illustrates a part of a wall system 11 which is formed by a pair of substantially identical, prefabricated portable panels 12 and 13 are supported in an upright position on a support surface, such as a floor, by means of adjustable supports 14. Each panel has a pair of opposed and substantially planar faces 16. While only two panels have been illustrated in Figure 1, it will be appreciated that any desired number of panels can be connected together with the adjacent panels being disposed in aligned or angled relationship so as to provide for the desired orientation of a wall system.

The panel 12 is of a substantially rectangular shape and is defined by substantially horizontally extending top and bottom edges joined by opposed vertically extending side edges. This general rectangular shape of the panel is defined by a rigid ring-like rectangular frame disposed internally of the panel, which frame is formed from a plurality of substantially channel-shaped rails extending longitudinally along each of the panel edges. One such channel-shaped rail 17 as illustrated in Figure 2, extends along the upper horizontal edge of the panel and a similar rail extends along the lower horizontal edge of the panel. The frame also includes substantially identical channel-shaped rails extending vertically along each side edge of the panel, one such side rail 18 being illustrated in Figure 3.

The rigid rectangular frame formed by the rails 17 and 18 has a pair of thin facing sheets 21 and 22 disposed on and fixedly secured to the opposite sides thereof, as

by being adhesively secured thereto. These facing sheets are normally of a thin sheet metal. The facing sheets 21 and 22 confine a honeycomb core 23 therebetween, which core 23 substantially totally occupies the region bounded by the rectangular frame. The facing sheets 21 and 22 are additionally each covered by a layer 24 which is of porous or fibrous sound-absorbing material.

The top of panel 12 is covered by a suitable top cap 26 which releasably engages the top rail 17. The vertical side edges of the panel each have an end cap 27 stationarily mounted thereon, which end cap is of channel-shaped cross section and extends throughout the height of the panel. Each end cap 27 is releasably connected to the adjacent side rail 18. As illustrated in Figure 3, end cap 27 has a pair of grooves 27A formed adjacent the opposite edges thereof, which grooves receive therein elongated flexible hinge members for permitting a pair of adjacent panels to be connected together. The end cap 27 also has a groove 28 extending longitudinally thereof and facing outwardly from each side of the panel, which groove 28 communicates with slots 29 formed in the rear wall of the groove. The grooves 28 and slots 29 accommodate therein brackets associated with auxiliary fixtures which are to be mounted on the wall panel, which fixtures may comprise file cabinets, shelves and the like. Such equipment and the manner in which it is mounted on wall panels of this general type is well known.

The core structure 23 utilizes the Helmholtz resonator principle, in that the core structure defines a plurality of small acoustical absorption chambers so that the panel will absorb a substantial quantity of the undesired sound wave frequencies which normally occur in office and industrial environments where panels of this type are normally utilized, which frequencies are normally in the range of 250 to 2000 cycles per second.

A Helmholtz resonator comprises, in its basic construction, a cell-like structure which defines a cavity or chamber therein, which chamber is closed by the walls of the cell except for a small opening formed in one of the walls for permitting the cavity to communicate with the surrounding environment. When properly designed, as by a proper selection of the volume of the chamber and the size of the opening, the cell will function as a resonator and absorb sound waves of a selected frequency range.

The core structure 23 is formed by a pair of superimposed honeycombs 31 and 32 positioned back-to-back. Each of the honeycombs 31 and 32 has a backing sheet 33 adhesively bonded to one face thereof, which backing sheets 33 are adhesively

70

75

80

85

90

95

100

105

110

115

120

125

130

bonded together to form a divider 34 which effectively separates and isolates the two honeycombs 31 and 32 from one another. The overall width of the two honeycombs 31 and 32, when bonded together in back-to-back relationship as shown in Figure 3, is substantially equal to the width of the frame rails 17 and 18. The outer surfaces of the honeycombs 31 and 32 are in turn adhesively bonded to the inner surfaces of the sheet metal skins 21 and 22, respectively, which skins overlie not only the exposed surfaces of the honeycombs but also the side surfaces of the frame. The honeycombs 31 and 32 and their associated backing sheets 33 are constructed of any suitable light-weight material, preferably a non-metallic material such as paper.

Each of the honeycombs 31 and 32 defines a plurality of cells 36 which, in the embodiment illustrated in Figures 2-4, are of a hexagonal cross section. Each cell 36 defines therein a chamber 37 which functions as the Helmholtz resonator chamber. The chamber 37 has the rearward or inner end closed by the divider 34, whereas the forward or outer end of the chamber is partially closed by the respective sheet metal skin 21 or 22. However, each of the skins 21 and 22 has a plurality of small openings or apertures 38 extending therethrough, which openings 38 are of extremely small cross-sectional area in relationship to the cross-sectional area of the cavity 37. Approximately one opening 38 communicates with one cavity 37 so as to form a Helmholtz resonator. While Figure 4 illustrates the openings 38 as being aligned with the central longitudinally extending axis of the associated cavity, nevertheless this central alignment is not necessary in order to form the Helmholtz resonator since the opening 38 can be offset from the axis of the cavity. Further, it is not necessary that an opening 38 communicate with each cavity 37 as long as there are a large number of resonators formed in this manner.

As representative of typical sizes which have been experimentally determined as effective for dampening the sound waves of selected frequencies, specifically the frequencies specified in the ASTM specifications, the cavity 37 normally has a size which lies within the range of between approximately $\frac{1}{2}$ inch and 2 inches, which dimension is measured between the opposed parallel sides of the cavity. The larger cavities are particularly suitable for use at lower frequencies, with the smaller cavities being desirable for use at higher frequencies. The openings 38 are preferably less than $\frac{1}{2}$ inch in diameter, and preferably approximately $\frac{1}{8}$ inch in diameter. The openings 38 have a cross-sectional area which is normally no greater than approximately 8

percent, and preferably no greater than approximately 5 percent, of the cross-sectional area of the cavity 37.

The fibrous layer 24 comprises a relatively thick flexible layer of fiberglass 39, which layer is also bonded to the adjacent sheet metal skin. The fiberglass layer 9 is preferably of low density, such as approximately one-half pound per cubic foot, so that its porosity enables it to efficiently absorb the higher frequency sound waves, and normally has an uncompressed thickness of between approximately $\frac{1}{2}$ and $\frac{1}{4}$ of an inch, preferably being in the range of between $\frac{1}{4}$ to $\frac{1}{2}$ inch in thickness. The fiberglass layer 39 is in turn covered by an outer covering 41, which covering 41 comprises a thin fabric which can be of suitable color or design so as to provide the panel with a decorative appearance.

To secure the outer covering 41 in position over the fiberglass layer 39, the panel is provided with a retainer structure extending around the periphery of the panel, which retainer structure comprises a substantially U-shaped retainer 42 secured to each of the frame rails and extending longitudinally along each of the horizontal and vertical edges of the panel. The U-shaped retainer 42 has a slot 43 therein which opens outwardly away from the edge of the panel, which slots permit the free edge of the outer covering or fabric 41 to be folded over into the slot. The covering 41 is securely retained in position by means of an elongated flexible retainer element 44 which is positioned within the slot 43 and elastically and resiliently engages the free edge of the fabric so as to clamp same to the retainer 42. The retainer element 44 comprises an elongated flexible tubular member which is preferably constructed of a resiliently deformable plastic material.

The sound waves in the surrounding environment, as experienced in a normal office or commercial building, are predominately in the range of between approximately 250 to 2000 cycles per second. When using a panel 12 which has the core structure formed from the two honeycombs 31 and 32, which honeycombs cooperate with the apertured sheet metal skins 21 and 22 so as to form a plurality of Helmholtz resonator chambers, the panel is able to absorb a high percentage of the undesired sound waves. The sound waves which pass through the openings 38 into the chambers 37 are effectively absorbed so that the sound waves are accordingly not reflected or retransmitted into the surrounding environment. The Helmholtz resonators as formed within the honeycombs 31 and 32 are particularly effective for absorbing the lower frequencies, such as in the range of 500 cycles per second, whereas these resonator cham-

bers in combination with the overlying fiberglass layer 39 is particularly effective in absorbing the higher frequencies, such as the frequencies in the range of 1000 to 5 2000 cycles per second. The fiberglass layer 39 specifically assists in controlling the higher frequency sound waves and thus, in conjunction with the Helmholtz resonator chambers, is able to extend the sound 10 absorption capability of the panel over a broader frequency range. The panel 12 is thus able to absorb a substantially higher percentage of the sound waves of undesired frequency, and yet at the same time the the 15 panel possesses substantial strength and durability resulting from the strength imparted to the panel by the honeycomb core and the sheet metal skins which are bonded to both the core and the frame. These skins, 20 by structurally connecting the core and the frame, thus effectively function as stressed skins and provide the panel with substantially increased rigidity, strength and durability. The panel can thus be utilized to 25 permit fixtures such as desks, bookshelves, file cabinets and the like to be hung thereon, as by utilization of the grooves 28 and slots 29. At the same time, the panel effectively functions as an acoustical sound absorber 30 of relatively high efficiency.

While the panel of Figures 2-4, which is not an embodiment of the present invention uses identical honeycombs 31 and 32 of a continuous and uniform cell size, an 35 embodiment of the present invention preferably uses a honeycomb having a plurality of different cell sizes to substantially extend the range of sound frequencies which can be absorbed by the panel. Providing the 40 panel with different cell sizes can be accomplished using several techniques.

A preferred technique for providing a multiple cell size in the honeycomb core is illustrated in Figure 5, wherein there is 45 illustrated a honeycomb 31¹ which is identical to the honeycomb 31 or 32 except that the honeycomb 31¹ is formed with continuous cells of at least two different sizes, there preferably being a similar number of each sized cell. More specifically, 50 the honeycomb 31¹ contains a first plurality of cells 46, each of which is of hexagonal configuration and defines therein a chamber 47. The honeycomb 31¹ also defines a 55 second plurality of cells 48, each of which defines a chamber 49 therein. The cell 48 is, in the illustrated embodiment, of a rectangular or diamond-shaped configuration, although the cell could be hexagonal or of 60 any other suitable configuration since the cells 46 and 48 may assume many different shapes. Other details of the panel of Figure 5 may be as described with reference to Figures 2, 3 and 4.

65 In a Helmholtz resonator chamber, the

sound absorption characteristic is determined by the volume of the chamber so that the chambers 47 and 49 are of substantially different volumes so as to define two different resonator chambers capable of absorbing substantially different sound wave frequencies. Since each of the chambers is of the same depth, as defined between the septum and the outer sheet metal skin, the ratio of volumes between the chambers 47 and 49 is likewise the same as the ratio between the cross-sectional areas. The chamber 49 thus has a cross-sectional area which is substantially less than the area of the chamber 47. For example, the chamber 47 may have a size of approximately 1 $\frac{1}{2}$ inches as measured between the opposed parallel sidewalls, whereas the chamber 49 may have an area substantially equivalent to a hexagonal chamber of $\frac{1}{2}$ inch dimension, so that the cross-sectional area of the chamber 47 is, in one preferred embodiment of the invention, between approximately 5 and 10 times greater than the area of the chamber 49.

In addition, the openings 38 which communicate with the chambers 47 are normally larger than the openings 38 which communicate with the chambers 49. In this preferred embodiment, the openings 38 communicating with chambers 49 normally have a diameter of about 0.125 inch, whereas the openings 38 which communicate with chambers 49 have a diameter of 0.090 inch.

Thus, by constructing the panel with 100 honeycombs 31 and 32 each of a multiple cell size, such as illustrated by the honeycomb 31¹, the panel will thus efficiently absorb a wider range of sound frequencies.

While Figure 5 illustrates the two different 105 cell sizes 46 and 48 as being uniformly distributed, it will be recognized that the different cells 46 and 48 can be randomly located if desired, or even concentrated in groups, without effecting the capability of 110 the panel to absorb the desired sound frequencies. For example, the different sized cells 46 and 48 could be located in rows or strips which extend vertically or horizontally of the panel, or in the alternative the different sized cells could be bunched within 115 substantially rectangular groupings in a manner similar to a checkerboard pattern if desired.

Further, while Figure 5 illustrates the 120 honeycomb 31¹, as having two different cell sizes, the present invention obviously encompasses providing the honeycomb with three or more cell sizes within the honeycomb.

As a further alternative, and referring to 125 Figures 6 and 7, the honeycomb core structure could again utilize honeycombs 31¹¹ and 32¹¹ which are each of a uniform and continuous cell size. However, in this variation, the cells 51 associated with the honey-

70

75

80

85

90

95

100

105

110

115

120

125

130

comb 31¹¹ would be small in relationship to the cells 52 formed in the honeycomb 32¹¹. Thus, the honeycomb 32¹¹ would thus be uniformly provided with larger cells 52 which would accordingly, be effective for absorbing the lower frequency sound waves, whereas the smaller cells 51 associated with the honeycomb 31¹¹ would, in combination with the fiberglass layer 39, be effective in absorbing the higher frequency sound waves.

This latter variation, as illustrated in Figures 6 and 7, is particularly desirable since it permits the utilization of commercially available honeycombs while still providing the panel with a core structure having different sizes of resonating chambers so as to effectively absorb a wide range of sound wave frequencies. In this variation, each of the sheet metal skins 21¹¹ and 22¹¹ are provided with an identical pattern of openings or apertures 38¹¹ formed therein, which openings would be positioned so that approximately one opening 38¹¹ would be aligned with each of the larger cells 52 associated with the honeycomb 32¹¹. Since the number of openings 38¹¹ formed in the skin 21¹¹ would be substantially less than the number of smaller cells 51, these openings 38¹¹ would accordingly, align with only a selected number of the cells 51. Again, each opening 38¹¹ would align with approximately only a single cell 51, and the number of resonating chambers formed by the cells 51 would be substantially equal to the number of chambers formed by the larger cells 52 on the other side of the panel. This arrangement would result in a large number of resonating chambers formed by the cells 51, which cells would be capable of absorbing the undesired sound frequencies, whilst the remaining cells 51 which are not aligned with any of the openings 38¹¹ would function solely to provide the panel with the desired strength and rigidity.

If desired, the skin 21¹¹ could be provided with a pattern of openings 38¹¹ corresponding with the pattern of the underlying honeycomb 31¹¹, so that approximately a single opening 38¹¹ would communicate with each cell 51.

In place of the fiberglass layer 39, the panel may be provided with a thick layer of carpeting 54 (Figure 6) if desired. Such layers of carpeting are also relatively effective in absorbing undesired sound frequencies. However, forming the outer layer 24 of fiberglass, rather than carpeting, is preferred since the fiberglass is substantially more effective in absorbing the undesired sound frequencies.

It will be appreciated that numerous variations can be made in the size of the individual sound absorption chambers, or in the volume and cross-sectional area thereof, and linewise substantial variations

can be made in the length and cross-sectional area of the openings formed in the sheet metal skins, so as to vary the sound absorption characteristics of the individual resonator chambers. These chambers can be designed to absorb the desired frequencies, and thus these variations in the chambers are encompassed within the present invention. In a further possible embodiment of the present invention, a substantial increase in the length of the individual sound absorbing chambers can be achieved, such as by eliminating the intermediate divider 34 whereby one opening 38 will communicate with only one end of the resulting longer chamber. In the alternative, small holes may be provided in the divider 34 or through the sidewall between adjacent chambers so that two axially aligned or side-by-side chambers can thus communicate with one another. This double chamber arrangement would still further vary the frequency absorption characteristics.

WHAT WE CLAIM IS:—

1. An interior space dividing wall formed from a plurality of portable interior upright space divider panels which are horizontally connected together in series, at least some of said panels being of an acoustical construction for absorbing sound waves, each said acoustical panel having opposed faces and a sound absorbing structure defined between said panel faces and extending substantially coextensively over 100 the area thereof, in which the sound absorbing structure includes first means for absorbing sound waves of a first frequency, said first means including a plurality of first Helmholtz resonators tuned for absorbing 105 sound waves of said first frequency, each of said first resonators being defined by a first interior chamber which is substantially closed and communicates with the surrounding environment through first opening means 110 which opens through one of the faces of the panel, and second means for absorbing sound waves of a second frequency which is substantially different from said first frequency, said second means including a 115 plurality of second Helmholtz resonators each tuned for absorbing sound waves of said second frequency, each of said second resonators being defined by a second interior chamber which is substantially closed 120 and communicates with the surrounding environment through second opening means which opens outwardly through one of the faces of the panel.

2. A wall system according to claim 1, 125 in which the sound absorbing structure includes third means for absorbing sound waves of a third frequency which is substantially different from said first and second frequencies, said third means comprising a 130

- layer of porous or fibrous sound absorbing material which is substantially coextensive with the pluralities of interior chambers.
3. A wall system according to claim 2, 5 in which the layer of sound absorbing material comprises a layer of fiberglass material.
4. A wall system according to any one of claims 1 to 3, in which the first and 10 second interior chambers are of different size.
5. A wall system according to claim 4, in which the first chamber has a cross sectional area as measured transversely with 15 respect to the respective opening means which is between approximately 5 and 10 times greater than the cross sectional area of the second chamber.
6. A wall system according to any one 20 of the preceding claims, in which the first opening means as communicating with each said first chamber has a cross sectional area which is substantially greater than the cross sectional area of said second opening 25 means as communicating with each said second chamber.
7. A wall system according to any one of the preceding claims, in which approximately one-half of said pluralities of first 30 and second resonators open outwardly through one face of the panel, and in which the remainder of said pluralities of said first and second resonators open outwardly through the other face of the panel.
8. A wall system according to any one 35 of the preceding claims, in which the panel is provided with a rigid ringlike frame of substantially rectangular configuration, said sound absorbing structure including a core structure positioned within the interior region defined within said frame, and a pair of thin platelike skins fixedly secured on opposite faces of the frame and extending across said interior region so that said interior chambers are defined therebetween, each of said skins having some of said first 45 and second opening means extending transversely therethrough for communication with the interior chamber.
9. A wall system according to claim 8, 50 in which the sheetlike skins comprise stress-carrying sheet metal members which are fixedly secured to the frame.
10. A wall system according to claims 8 55 or 9, in which the core structure comprises a honeycomb layer which is confined between said skins and is adhesively secured thereto.
11. A wall system according to any one 60 of claims 1 to 9, in which the sound absorbing structure includes a honeycomb layer having said pluralities of said first and second chambers formed therein.
12. A wall system according to claim 65 11, in which the sound absorbing structure has first and second honeycomb layers disposed in adjacent back-to-back relationship, each of said honeycomb layers having said chambers formed therein, and divider means positioned between and engaged with the adjacent inner faces of the two honeycomb layers for substantially isolating the chambers of the two layers from one another, the chambers of one layer communicating through the other face of the panel. 70
13. A wall system according to any one of claims 8 to 12, in which the layer of sound absorbing material is positioned exteriorly of an overlies the said skins. 75
14. A wall system according to any one of the preceding claims, in which a thin sheetlike covering layer of fabric material extends over each face of the panel and defines the exterior face thereof. 80
15. A wall system according to any one of claims 2 to 14, in which said second frequency is substantially greater than said first frequency, and in which said third frequency is substantially greater than said second frequency. 85
16. A wall system according to any one of the preceding claims, in which each acoustical panel has a thin flexible covering of fabric-like material overlying each side of the panel and defining the opposed faces 90 thereof. 95
17. A wall system incorporating therein a wall panel substantially as described hereinbefore with reference to Figure 5 of the accompanying drawings. 100
18. A wall system incorporating therein a wall panel substantially as described hereinbefore with reference to Figures 6 and 7 of the accompanying drawings.
19. A portable interior space divider 105 panel having opposed faces and a sound absorbing structure defined between said panel faces and extending substantially co-extensively over the area thereof, in which the sound absorbing structure includes first 110 means for absorbing sound waves of a first frequency, said first means including a plurality of first Helmholtz resonators tuned for absorbing sound waves of said first frequency, each of said first resonators being 115 defined by first interior chamber which is substantially closed and communicates with the surrounding environment through first opening means which opens through one of the faces of the panel, and second 120 means for absorbing sound waves of a second frequency which is substantially different from said first frequency, said second means including a plurality of second Helmholtz resonators each tuned for absorbing 125 sound waves of said second frequency, each of said second resonators being defined by a second interior chamber which is sub-

stantially closed and communicates with the surrounding environment through second opening means which opens outwardly through one of the faces of the panel.

REDDIE & GROSE,
Agents for the Applicants,
16, Theobalds Road,
London, WC1X 8PL.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1980.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

1572177

COMPLETE SPECIFICATION

3 SHEETS

*This drawing is a reproduction of
the Original on a reduced scale
Sheet 1*

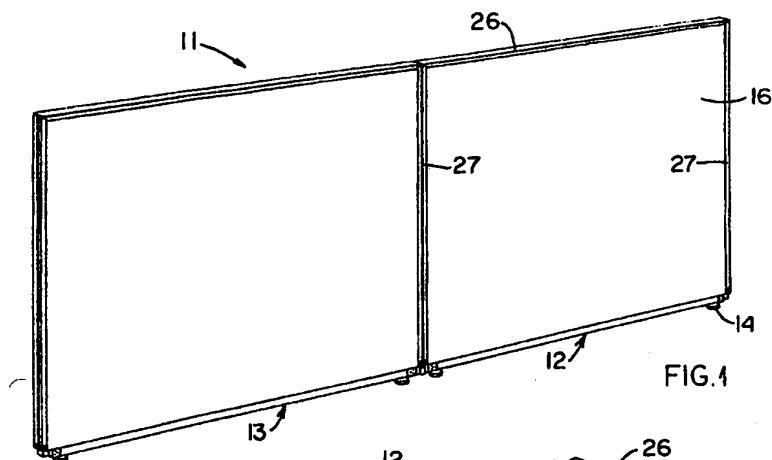


FIG. 1

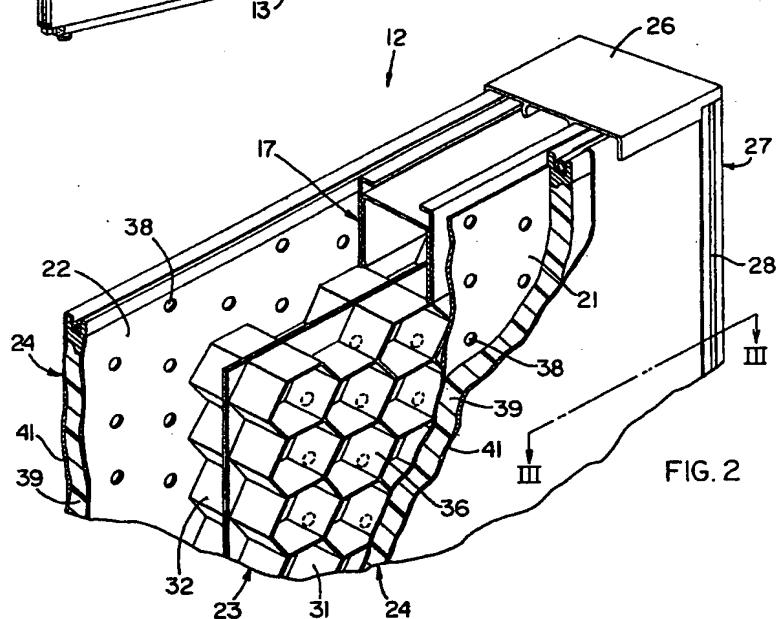


FIG. 2

1572177 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of
the Original on a reduced scale
Sheet 2

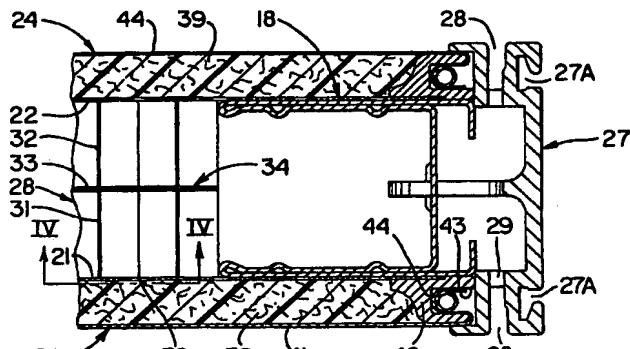


FIG. 3

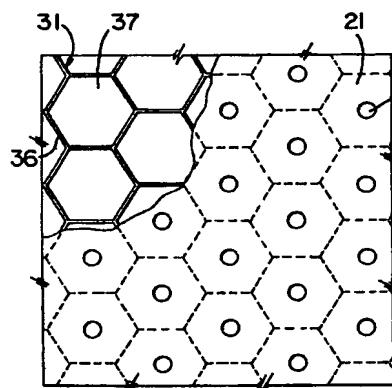


FIG. 4

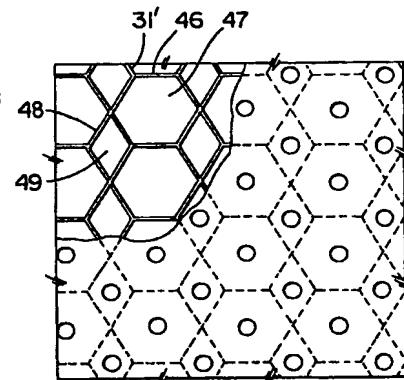


FIG. 5

1572177 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of
the Original on a reduced scale
Sheet 3

